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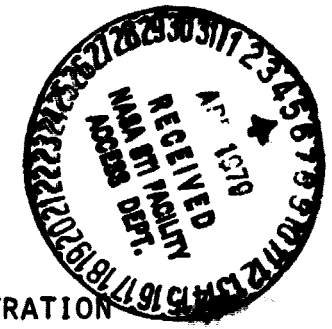
MODELS AND TECHNIQUES FOR EVALUATING THE EFFECTIVENESS OF AIRCRAFT COMPUTING SYSTEMS

PRINCIPAL INVESTIGATOR

JOHN F. MEYER



PREPARED FOR:
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
LANGLEY RESEARCH CENTER
HAMPTON, VIRGINIA 23365
G.E. MIGNEAULT - NASA TECHNICAL OFFICER
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DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
SYSTEMS ENGINEERING LABORATORY
THE UNIVERSITY OF MICHIGAN, ANN ARBOR

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MODELS AND TECHNIQUES FOR EVALUATING THE EFFECTIVENESS OF AIRCRAFT COMPUTING SYSTEMS

Semi-Annual Status Report Number 5

Covering the Reporting Period

1 June 1978 - 30 November 1978

Prepared For
National Aeronautics and Space Administration
Langley Research Center
Hampton, Virginia 23365
G. E. Migneault, NASA Technical Officer
NASA Grant NSG 1306

John F. Meyer, Principal Investigator
Department of Electrical and Computer Engineering
Systems Engineering Laboratory

SEL Report Number 129

The University of Michigan
Ann Arbor, Michigan 48109

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1. INTRODUCTION

This report is the fifth Semi-Annual Status Report on the research project "Models and Techniques for Evaluating the Effectiveness of Aircraft computing Systems" being conducted for the NASA Langley Research Center under NASA Grant 1306. The subject grant was initiated 1 May 1976 for a one year period, extended 1 May 1977 for a second one year period, and extended 1 June 1978 for a third one-year period. This report concerns work accomplished during the first half of the third year, that is, the period from 1 June 1978 to 30 November 1978, hereafter referred to as the reporting period.

The purpose of this research project is to develop models, measures, and techniques for evaluating the effectiveness of aircraft computing systems. By "effectiveness" in this context we mean the extent to which the user, i.e., a commercial air carrier, may expect to benefit from the computational tasks accomplished by a computing system in the environment of an advanced commercial aircraft. Thus, the concept of effectiveness involves aspects of system performance, reliability, and worth (value, benefit) which must be appropriately integrated in the process of evaluating system effectiveness. Specifically, the primary objectives of this project are:

(1) The development of system models that can provide a basis for the formulation and evaluation of aircraft computer system effectiveness,

(2) The formulation of quantitative measures of system effectiveness, and

(3) The development of analytic and simulation techniques for evaluating the effectiveness of a proposed or existing aircraft computer.

Midway through the first year of the project, a decision was made to decouple the performance and reliability aspects of effectiveness from the worth aspect, and to focus the effort on performance and reliability issues. As argued when this research was originally proposed and as substantiated by research accomplished to date, the issues of performance and reliability must be dealt with simultaneously in the process of evaluating the effectiveness of "degradable" computing systems. The term "performability" was introduced to refer to this unification of performance and reliability, and performability was identified with effectiveness in the preceding related objectives.

During the first two years of the project [1]-[4], the effort was carried to the point where objectives (1) and (2) were satisfactorily accomplished. (There is a need for further development of model construction and solution methods aimed at improving the efficiency of performability evaluation, but this is regarded as part of objective (3).) Considerable progress was also made with respect to objective (3), culminating in a relatively comprehensive evaluation exercise involving the SIFT computer [4]. Based on these results, the effort proposed for the third year had the following objectives (see[5]):

(i) Clarification of the concepts, theorems, formulas, algorithms, and evaluation methods developed during the first two years of the project,

(ii) Further substantiation of the feasibility of performability evaluation via continued investigation of specific applications,

(iii) Continued development of prototype performability evaluation tools, i.e., the METAPHOR package and its resident evaluation programs, and

(iv) **Development of basic results aimed at increasing the efficiency of performability evaluation and extending the limits of its applicability.**

The first of these objectives was identified as the principal objective and has been the focus of most of our activity during the reporting period. Section 2 of this report reviews the manpower effort proposed for the current year and lists the personnel involved in conducting the investigation, along with their levels of effort during the reporting period. Section 3 summarizes the work performed during the period.

It should be noted that, beginning with this Status Report, we are adopting a format which differs from that of earlier reports [1]-[4]. Previously, each Status Report was a single document which presented a detailed description of the work performed throughout the reporting period. Although comprehensive, this method of reporting often required that a specific piece of work be described prior to some naturally defined point in time when the desired intermediate or final results were obtained. This led to either a delay of the Status Report so that the work could be carried to a more appropriate reporting point or to documentation of the work in more than one Status Report. Hence, with the encouragement of our Technical Officer, Earle Migneault, we are adopting a new reporting method wherein Technical Status is simply summarized (Section 3 of this report) and the details are left to more self-contained technical reports, dedicated to specific topics and written when it is deemed necessary. Two such reports [7], [8] are enclosed with this Status Report.

In general, however, we envision that these technical reports will be issued during the reporting period as well as in conjunction with a specific Status Report.

2. PERSONNEL

In the proposal for the second extension [5], it was estimated that the following effort would be required during the third year.

Principal Investigator

100%, two months, summer
25%, nine months, academic year

Two Graduate Student Research Assistants

50%, two months, summer
20%, eight months, academic year

Secretary

25%, twelve months, calendar year

During the reporting period from 1 June 1978 to 30 November 1978, personnel and their levels of effort have been as follows.

Principal Investigator

John F. Meyer: 100%, June, August 1978
25%, September-November 1978

Graduate Student Research Assistants

David G. Furchtgott: 50%, June-August 1978
15%, September-November 1978

Liang T. Wu: 50%, June-August 1978
10%, September-November 1978

Secretary

Sara L. Patterson: 25%, September-November 1978

3. SUMMARY OF TECHNICAL STATUS

As stated in the introduction, our activity during the reporting period has focused mainly on "clarification of the methodology," the principal objective of the research to be performed during the current year. In keeping with the proposed approach (see [5], Section 3.1), we are concerned with clarifying performability concepts, theory, and evaluation methods for each of two audiences:

A) A "general audience" comprised of persons who are interested in using data obtained from performability evaluations of aircraft computers but need not be interested in how the evaluations are implemented, e.g., certain NASA personnel, aircraft computer users (airframe manufacturers), air carriers, etc.

B) A "specific audience" comprised of persons responsible for assessing the advantages and disadvantages of the methodology and persons responsible for carrying the development of performability evaluation programs (such as METAPHOR) beyond the protopype stage and into final production, e.g., Langley Flight Electronics Division personnel, personnel contracted by FED, persons responsible for aircraft computer evaluation and certification, etc.

Clarification is regarded as a distinct problem for each audience although, as anticipated when this work was proposed, there are cases where the same explanation is appropriate for both audiences. In particular, we have found the latter to be true when clarifying the "input" and "output" of the methodology, that is, explanations of basic concepts on the input side and discussions of applications experience on the output side.

Our effort in this regard resulted in three documents which clarify various aspects of performability evaluation:

1. Performability Evaluation of Fault-Tolerant Multiprocessors [6],
2. Performability Evaluation of the SIFT Computer [7],
3. METAPHOR (Version 1): Programmer's Guide [8].

The first of these documents is a paper that was presented at the 1978 Government Microcircuit Applications Conference (GOMAC). A copy of this paper, identical to that submitted to GOMAC, was sent to NASA Langley on 30 August, 1978. The last two documents are Technical Reports (SEL Reports 127 and 128, respectively), which are enclosed with this Status Report. (Since the end of the reporting period, SEL Report 127 has been submitted and accepted for presentation at the Ninth International Symposium on Fault-Tolerant Computing, Madison, Wisconsin, June 20-22, 1979.)

Table 1 summarizes the material clarified in these documents according to audience (see above) and to the type of result considered (see [5], Section 3.1). Entry number "n.m" in the table refers to section m of document n (as enumerated above).

In addition to this activity concerning clarification, some work was also done in connection with proposed objectives (ii) and (iv) (see Section 1 of this report). Regarding applications (objective (ii)), considerable time was devoted early in the reporting period to completing the SIFT evaluation exercise. In the interest of continuity, the documentation of

Type of Result	Audience	
	General (A)	Specific (B)
Concept	1.1,1.2,2.1,2.2	1.1,1.2,2.1,2.2
Theorem	None	None
Formula	None	2.3
Algorithm	2.4	2.4
Program	3.1	3.1,3.7
Application	1.3,2.4	1.3,2.4

Table 1

this effort was included in the previous Semi-Annual Status Report [4]. Regarding basic development (objective (iv)), some further thought was given to modeling techniques such as time "phasing" and state "lumping" for the purpose of simplifying the computation of trajectory set probabilities (see [3], pp. 53-72). This effort is directed toward preparation of a technical report (during the next reporting period) which clarifies these techniques for the "specific audience." A small amount of effort has also been devoted to describing and illustrating performability modeling concepts in a more general, system oriented (rather than computer oriented) context. This work was initiated in connection with a presentation on "Modeling Concepts for Unifying Performance and Reliability Evaluation" given at the Symposium on Modeling and Simulation Methodology, Rehovot Israel, August 13-18, 1978. We were invited to prepare a written version of this presentation for inclusion in a book edited by B. P. Ziegler, but, in the face of other reports which we felt had higher priority (particularly [7]), we were unable to meet the deadline for publication. We intend, however, to resume this effort during the next reporting period and write up the results as a technical report.

Finally, our activity during the reporting period included participation in three technical conferences: the Eighth International Symposium on Fault-Tolerant Computing (Toulouse, France in June; see [9]), the Symposium on Modeling and Simulation Methodology (Rehovot, Israel in August; see above), and the 1978 Government Microcircuit Applications Conference (Monterey,

California in November, see [6]). The audiences at these meetings represented a broad range of technical interests, providing us the opportunity to discuss and receive valuable feedback on most all aspects of our work.

4. REFERENCES

[1] J. F. Meyer, "Models and techniques for evaluating the effectiveness of aircraft computing systems," Semi-Annual Status Report Number 1, NASA Grant NSG 1306, November, 1976.

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[5] J. F. Meyer, "Models and techniques for evaluating the effectiveness of aircraft computing systems," Proposal for extension of NASA Grant NSG 1306, submitted to NASA Langley Research Center, April 1978.

[6] D. G. Furchtgott and J. F. Meyer, "Performability evaluation of fault-tolerant multiprocessors," 1978 Government Microcircuit Applications Conference Digest of Papers, Monterey, California, pp. 362-365, November, 1978.

[7] J. F. Meyer, D. G. Furchtgott, L. T. Wu, "Performability evaluation of the SIFT computer," SEL Report No. 127, Systems Engineering Lab, The University of Michigan, Ann Arbor, MI, January 1979.

[8] D. G. Furchtgott, under the supervision of J. F. Meyer, "METAPHOR (Version 1): Programmer's guide," SEL Report No. 128, Systems Engineering Lab, The University of Michigan, Ann Arbor, MI, January 1979.

[9] J. F. Meyer, "On evaluating the performability of degradable computing systems," Proc. 1978 Int'l Symp. on Fault-Tolerant Computing, Toulouse, France, pp. 44-49, June, 1978.